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# Stagnation in body mass index in Denmark from 1997/1998 to 2004/2005, but with geographical diversity

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## ABSTRACT

**INTRODUCTION:** We analyzed the trend in body mass index (BMI) as well as in the prevalence of overweight and obesity among Danish adults, mainly women, from 1997/1998 to 2004/2005 and evaluated any regional differences.

**MATERIAL AND METHODS:** Data were drawn from two cross-sectional population-based studies conducted in parallel in Aalborg and Copenhagen from 1997/1998 and 2004/2005. Height and weight were measured in a total of 7,487 participants in the two cohorts.

**RESULTS:** In the total cohort, we found no significant difference in BMI from 1997/1998 to 2004/2005 ( $p = 0.828$ ). There was an increase in BMI in Aalborg of 0.32 ( $p = 0.030$ ), while in Copenhagen we observed a statistically significant decrease in BMI of 0.30 ( $p = 0.017$ ). The difference in change over time in BMI between the two regions was significant ( $p = 0.002$ ). Also the difference in the trend in prevalence of overweight and obesity was statistically significant between the two cities ( $p = 0.010$ ).

**CONCLUSION:** Our results indicate that the obesity epidemic is leveling off – at least among women – and that it may even be receding in Copenhagen. Nevertheless, the absolute average BMI values and the prevalence of overweight and obesity in both cities are high which underlines the need for further initiatives to prevent obesity-related health risks in the future.

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**TRIAL REGISTRATION:** not relevant.

century, whether data were self-reported or objectively measured, but the picture is heterogeneous [1, 2, 4, 5-9]. A study based on data from 1964 to 1994 showed a decline in BMI among middle-aged Danish women, but a rising BMI among younger adults of both sexes, particularly among middle-aged and elderly men. Other Danish studies have shown a rise in overweight and obesity among both sexes with the number of overweight/obese people growing with increasing age, but a greater increase of overweight/obese people over time in the youngest age groups [5-7]. A BMI increase has also been observed among children and adolescents [8-10], though recent data suggest stagnation in BMI among children, while the BMI of adolescents continues to rise [11]. Hence, it is difficult to achieve a clear picture of trends in the occurrence of obesity in Denmark.

The most thorough samples of objectively measured BMI data have been collected in connection with

## ORIGINAL ARTICLE

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Most published studies of body mass index (BMI) in the Danish population are of an earlier date, and they are based primarily on self-reported data known to be biased by systematic under-estimation of weight and over-estimation of height; a bias that increases with increasing BMI [1-3].

Previous studies have shown a rise in the number of overweight and obese people in Denmark over the past



East versus west? There is a geographical diversity in the development of body mass index in Denmark. Photo: Bigstock.

the examination of young men eligible for military service. Lately, these data have shown stagnation in the BMI trend, even though these findings might be biased by a large number of obese men being exempt from examination [12]. A recent report on cardiovascular risk factors comprising data from the western part of Copenhagen showed a decrease in BMI among both men and women since 2000 [13]. Whether there are regional differences in the BMI trend remains unknown.

From the DanThyr project we had data on the height and weight of 4,649 participants in 1997/1998 and 3,570 participants in 2004/2005, mainly women. The participants were evenly distributed between Aalborg and Copenhagen. With these reliable and relatively new, objectively measured data from a broad spectrum of the female and elderly male population in both Eastern and Western Denmark, we wanted to analyze the overall trend in BMI as well as any regional differences.

#### MATERIAL AND METHODS

Data were collected from the DanThyr project, obtained from two matched, cross-sectional studies before and after iodization of salt (1997/1998 and 2004/2005).

##### Cross-sectional study 1997/1998 (C1)

From the Civil Registration System, a total of 40,233 Danish-born persons from the city centre of Aalborg and from Copenhagen's Northwest Quarter and Østerbro split into five groups (women aged 18-22, 25-30, 40-45, 60-65 and men aged 60-65 years) were randomly drawn and were given randomized numbers. Among these,

9,274 were invited by letter, and 4,649 (50.1%) participated of whom 46.6% were from Copenhagen and 54.6% from Aalborg.

##### Cross-sectional study 2004/2005 (C2)

The method was exactly the same as in C1. This time, 7,661 persons were invited of whom 3,570 (46.6%) participated (44.5% in Copenhagen and 49.0% in Aalborg). None of the participants from C1 were invited to C2. The inclusion procedure made sure that the participants were evenly distributed on the five sex and age groups in both cities. The participation rate was slightly lower in 2004/2005 than in 1997/1998 – a tendency generally seen over time in other studies. In both C1 and C2, the participation rate was higher in Aalborg than in Copenhagen. The difference in participation rate between the two studies should therefore have no influence on the analysis of regional differences.

For further details, see the original articles [14, 15].

All participants from both C1 and C2 answered questionnaires addressing smoking habits and education; furthermore, blood samples were taken. Wearing light clothes and no shoes, the participants were all weighed on calibrated analogue scales. Body height was measured with stadiometers in cm without shoes. Two different observers did the measurement in Aalborg and Copenhagen. In Aalborg, the same observer did the measurements in both 1997/1998 and 2004/2005, whereas in Copenhagen observers were different in 1997/1998 and 2004/2005.

##### Applied data

For our analysis, we calculated BMI as (body weight in kg)/(body height in m)<sup>2</sup>. According to the WHO's international criteria, overweight is defined as a BMI  $\geq 25$  kg/m<sup>2</sup> and obesity as a BMI  $\geq 30$  kg/m<sup>2</sup>. We used body weight minus 1 kg for clothes. Smoking status was defined as either "smoker" or "never smoker". Education was divided into four groups: "No vocational education", "Short vocational education", "Intermediate vocational education" and "Long vocational education". Students were allocated to groups according to the education they were currently attending.

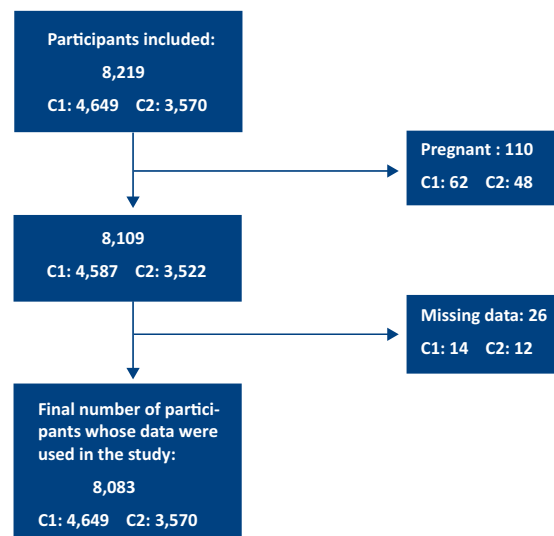
Smoking habits, education and thyroid function are considered mediators of change in BMI over time rather than confounders, because changes in these parameters could contribute to the changes in BMI. Since they are possible intermediate variables, they were not included in the final analysis, but their effects are described separately.

##### Statistics

The data analyses were made with SPSS version 17.0. Multivariate analysis with linear regression models

FIGURE 1

Data selection flow chart. Participants who were pregnant during the investigation were excluded as were participants for whom data were missing.



C1 = cohort 1, 1997/1998; C2 = cohort 2, 2004/2005

and logistic regression analysis were applied. In all models, adjustment was made for age and sex, and in multivariate models further adjustment was made for smoking, educational level and thyroid-stimulating hormone (TSH).

*Trial registration:* not relevant.

## RESULTS

Of the 8,219 participants in the two cohorts, 8,083 were eligible for these analyses, **Figure 1**.

In the total cohort, we found no significant difference in BMI between 1997/1998 and 2004/2005 ( $p = 0.828$ ). There was a significant increase in BMI in Aalborg of  $0.32 \text{ kg/m}^2$  ( $p = 0.030$ ) from 24.60 to 24.92 between 1997/1998 and 2004/2005, while in Copenhagen we observed a statistically significant decrease in BMI of  $0.30 \text{ kg/m}^2$  ( $p = 0.017$ ) from 24.99 to 24.69 in the same period, **Table 1**. The difference in change over time in BMI between the two regions was significant ( $p$  for interaction = 0.002).

Serum TSH was considered a possible mediator since – following iodization of salt – median serum TSH increased from 1.30 to 1.51 mU/l from the first to the second examination [15]. Inclusion of log TSH in the multivariate analysis did, however, not influence the BMI trends. Tobacco smoking was another possible mediator since smoking prevalence decreased from 37 to 27% from C1 to C2, and there was a correlation between smoking and BMI with a BMI of  $24.3 \text{ kg/m}^2$  among smokers and  $25.0 \text{ kg/m}^2$  among non-smokers. Inclusion of smoking status did, however, not influence BMI data in the multivariate models. Education could be a mediator for the changes in BMI as the number of people with a high level of vocational education rose from 24 to 28% and we found a significant association between education and BMI ( $25.4 \text{ kg/m}^2$  in the group with no vocational education and  $24.1 \text{ kg/m}^2$  in the group with a long education,  $p < 0.001$ ). Still, inclusion of education only entailed a small change in BMI estimates. When adjusting for all mentioned parameters in one model, as shown in Table 1, the BMI increase in Aalborg was no longer significant ( $p = 0.384$ ), but the decrease in Copenhagen remained significant as did the interaction for the different trends in BMI between the two regions ( $p$  for interaction = 0.001).

In contrast to previous studies [5-7], there was no trend towards a higher BMI among the youngest age groups when data were restratified according to sex and age groups. There was, however, a trend towards a decrease in BMI in all age groups in Copenhagen from 1997/1998 to 2004/2005, but none of these observations were statistically significant.

In Aalborg, a trend towards an increase in BMI in all

**TABLE 1**

Group	n	BMI		BMI <sub>multivar</sub> <sup>a</sup>	
		kg/m <sup>2</sup>	p value	kg/m <sup>2</sup>	p value
Total			0.828		0.432
C1	4,573	24.81		24.66	
C2	3,510	24.81		24.58	
D (C2-C1)	–	0.00		0.08	
Aalborg			0.030		0.066
C1	2,401	24.60		24.42	
C2	1,764	24.92		24.69	
D (C2-C1)	–	0.32		0.27	
Copenhagen			0.017		0.012
C1	2,172	24.99		24.90	
C2	1,746	24.69		24.55	
D (C2-C1)	–	–0.30		–0.45	

BMI = body mass index; BMI<sub>multivar</sub> = BMI with adjustment for thyroid-stimulation hormone, smoking and education by multivariate analysis with linear models and logistic regression; C1 = cohort 1, 1997/1998; C2 = cohort 2, 2004/2005.

a) For the BMI<sub>multivar</sub> analysis the number was a little smaller because of missing data on some of the model parameters.

Body mass index trend between 1997/1998 (C1) and 2004/2005 (C2) in a sex- and age-specific random sample from Aalborg ( $n = 4,165$ ) and Copenhagen ( $n = 3,918$ ). Participants were women aged 18-22, 25-30, 40-45, 60-65 and men aged 60-65 years. All models were adjusted for age and sex. Weight was subtracted 1 kg for clothes.

**TABLE 2**

Group	BMI ≤ 25	25 < BMI ≤ 30	BMI > 30
<i>1997-1998</i>			
Total	59.5	27.6	12.8
Aalborg	61.2	27.5	11.3
Copenhagen	58.1	27.8	14.2
<i>2004-2005</i>			
Total	59.0	28.1	12.9
Aalborg	58.0	29.7	12.3
Copenhagen	60.0	26.4	13.5

Trend in body mass index (BMI, kg/m<sup>2</sup>) classes between 1997/1998 and 2004/2005 in an age- and sex-specific random sample from Aalborg ( $n = 4,165$ ) and Copenhagen ( $n = 3,918$ ). All analyses were adjusted for age and sex. The values are percentages.

age groups from 1997/1998 to 2004/2005, but it did not reach a level of statistical significance in any of the age groups.

**Table 2** shows the prevalence of overweight and obesity in the total cohort and in Aalborg and Copenhagen, respectively. The trend in distribution of overweight reflects the general trend in BMI in the two cities and in the total cohort with a rising prevalence of overweight and obese people in Aalborg from 38.8 to 42.0% ( $p = 0.040$ ) as well as a declining prevalence of overweight and obese people in Copenhagen from 42.0 to 39.9% ( $p = 0.105$ ) from 1997/1998 to 2004/2005. In 1997/1998 more people in Copenhagen than in Aalborg had a BMI  $\geq 25 \text{ kg/m}^2$ , whereas the opposite pattern was observed in 2004/2005. There was a statistically significant difference in the change of weight class distribution between the two cities ( $p$  for interaction = 0.010).

## DISCUSSION

Our results showed an unchanged average BMI from 1997/1998 to 2004/2005 in the total cohort reflecting

a possible stagnation in the BMI trend in Denmark. However, there was a marked difference in the change of BMI when we compared the two Danish regions of Aalborg and Copenhagen. We observed a significant increase in average BMI in Aalborg in the period, while a decrease in average BMI was observed in Copenhagen. According to the absolute BMI values, people were not in general more overweight in Aalborg than in Copenhagen, they were simply less overweight in 1997/1998 and have subsequently reached about the same level of BMI as seen in Copenhagen in 1997/1998.

Our data are from two identical studies with a well-defined protocol which assures a completely identical selection and implementation of the two studies. All participants were citizens of urban areas.

Considerable heterogeneity in BMI between different sex and age groups and over time has been shown in previous studies of BMI in Denmark, but most of these studies were based on non-self-reported data of an earlier date, only investigated the population of Copenhagen or only included men or children/adolescents [2, 6, 10, 11, 16]. One previous study showed BMI stagnation, and in middle-aged women even a decrease [2]. But contrary to all previous studies with non-self-reported data, we find no significant increase among the youngest age groups. In Copenhagen, there is even a trend towards a decrease among young women. This is a clear change of the trend that we have seen for some years with the highest increase in overweight and obesity in the youngest generations [4, 6, 7]. A possible explanation for this maybe that more young women today have a higher socio-economic status than before – a factor known to influence BMI [10, 12, 17, 18].

Furthermore, we observed stagnation in the BMI trend of the total cohort. This finding has not previously been published, either in studies using self-reported [5, 9] or in studies reporting objectively measured data [1, 2, 4, 6-8]. It is possible that these results reflect the trend for women only, since the proportion of men participating in the present study was modest. But still, even among elderly men in Copenhagen, BMI tended to decrease; while among men in Aalborg, BMI increased a little, albeit not significantly. The results are also supported by newly published health profiles from Copenhagen and Jutland which – although based on self-reported data – confirm both the declining BMI trend in Copenhagen and the increasing trend in Jutland in both sexes [19, 20].

A prominent finding was the regional difference in BMI change during the period which was statistically significant. Log TSH, smoking and educational level could be mediating factors in the BMI trend since we know that all of these factors influence BMI and have not been static in the period. But it did not explain the difference

between the cities which was still statistically significant when adjusting for all of these factors. The data available did not allow for analysis of any effects of differences in physical activity or economic status.

The Aalborg trend follows that observed in other studies during the past century [1, 2, 4-9], while the decrease in BMI in Copenhagen observed in the present study contrasts with previous investigations. A possible explanation for the geographical differences observed maybe that certain trends or life-style changes start in Copenhagen and then spread to other parts of the country. If this is the case, we would expect a BMI stagnation in Aalborg within a few years corresponding to that seen in Copenhagen.

When we analyzed the distribution of data on weight classes, the changes observed reflected the trend of average BMI, excluding the possibility that our findings could be due to a greater dispersion of BMI.

Even though it is a positive sign that we observed a stagnation in BMI in such a large cohort, the absolute average BMI value of 24.81 kg/m<sup>2</sup> in the total cohort (24.69 kg/m<sup>2</sup> in Copenhagen and 24.92 kg/m<sup>2</sup> in Aalborg) is disturbingly high. As seen in Table 2, this average reflects a BMI  $\geq$  25 kg/m<sup>2</sup> in more than 40% of the total cohort in 2004/2005. Especially among the elderly, a high BMI is problematic, since the composition of body components changes with age towards a larger proportion of fat – and thereby towards a greater health risk – within the same BMI range [1].

Despite more optimistic findings than in previous Danish studies, preventing obesity-related health problems remains a major issue.

## CONCLUSION

Altogether, our results show stagnation in BMI in the total cohort, but with great geographical differences: a decrease in Copenhagen and an increase in Aalborg. Part of this change in BMI over time could be explained by differences in log-TSH, smoking habits and education. This reflects that life style changes between the two regions are of some importance, but it did, however, not affect the different trends observed in the two regions.

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**CONFLICTS OF INTEREST:** none

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